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REPORT

ON THE

QUEBEC WATER WORKS.

By THOS. C. KEEFER.

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REPORT

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QUEBEC WATER WORKS.

HAMILTON, 30th JUNE, 1860.

W. SHORDICHE, Esq., Manager Quebec Water Works, Quebec.

SIR,

I have the honor herewith to submit my report "on the various and best modes by which a greater supply of water could be obtained through the present line of pipes"—as directed in your letter of instructions of 21st February last. I was also then requested "to report on the practicability of a scheme which was lately proposed by a certain Gentleman, and adopted by the City Council, which scheme, although it had been in operation since the 20th of January, had not turned out to be altogether satisfactory." The scheme alluded to had been abandoned previous to my arrival in Quebec—but as there had been some complaint made against the summary removal of the machinery by which it was attempted, I may still be expected to refer to it.

The water having fallen away from the highest streets within the City, some of which were at least two hundred feet under the source of supply, it was supposed that by forcing more water into the pipe at Lorette, the difficulty could be remedied—and for this purpose a wheel was placed in the well of the Gate-House (or chateau d'eau) which weel was driven by a line of shafting from another wheel turned by the fall of water over the dam. This first wheel was in its action similar to the rotary or centrifugal pumps now generally applied to coffer-dams, wrecks, or places where a large quantity of water is to be lifted a few feet in the shortest possible time and without regard to cost of motive power. The water power by which this pump was worked was derived from the surplus of the River St. Charles, flowing over the dam built for regulating the supply at Lorette. In estimating the value of this power it must be borne in mind that the greatest deficiency of water in the City will be in the dry summer and cold winter months when the flow of the St. Charles is a minimum. The length of the dam is two hundred feet and the fall four and a quarter feet, the depth of water flowing over the breast of this dam being reduced in dry seasons to two inches. This would give a discharge of abont fifty cubic feet per second, or less than twenty horse power on the whole fall of the dam. The best wheels could not be depended upon, under these circumstances, to furnish more than about fifteen horse power for the purpose of aiding the delivery of the pipe. Now if the water in the City falls away from the Grande Allée to a point one hundred feet below it, the supply at Lorette must be lifted at least a corresponding number of feet to counterbalance this depression. The whole supply, therefore, say three hundred cubic feet per

minute, must first be lifted perpendicularly one hundred feet at Lorette,—an operation which would call for a power at least four times greater than could be afforded by the St. Charles, at the dam, in midsummer or midwinter. This shews that if all the available water power were applied it would be utterly insufficient to keep the water on the Cape ; but it is evident that raising the water at Lorette will not cause a corresponding elevation in the pipes in the Upper Town, so long as the draught in Lower Town continues,—because the additional pressure would cause a proportional increase of the discharge due to that draught.

In dismissing this question it may be observed that no method can be adopted for forcing an additional quantity of water into the present line of pipes, which does not involve *increased pressure* in those pipes exactly in proportion to the effect produced,—and if any appreciable effect is to be produced in the City, not only must large steam power be provided at Lorette, but the dangerous experiment of throwing an additional pressure of one hundred feet, or more, upon the pipes under the St. Charles (where they are already under a head of four hundred and eighty-six feet) must be made.

The main is not only doing all it can do—but it is affording what with some provision for storage in the city ought to be an abundant supply for more than the present population. Of the whole quantity of water delivered into the City not more than one fourth is *used*, the remainder being wasted—except in so far as that which is allowed to run into closets or is used to prevent freezing in winter, may be considered as usefully, however extravagantly, employed. If the number of consumers can be estimated from the number of service pipes laid into the houses, according to the well ascertained average of Montreal and other cities upon both sides of the Atlantic, the population actually supplied by the pipes in Quebec should not exceed 30,000, in which case the consumption of water averages about one hundred gallons per diem to each individual ;—an unheard of quantity even where the waste is most profuse. It will be admitted that if the limited population now having access to the pipes, consumes all the water intended for 100,000 people,—not only exhausting the capacity of the main but rendering it useless in the higher districts, and diminishing its efficiency for five purposes at all points,—some attempt should be made to determine how far this consumption is legitimate, before any effort beyond that of storing the night delivery is made to increase the supply. If either from ignorance of the capacity of the works or from recklessness, waste exists, will it not increase with the additional means of exercising it ? and what guarantee is there that the same deficiency will not be felt in a very short time after an additional supply is obtained ?

The slow extension of the distributing pipes through narrow and rocky streets, upon the first introduction of the water into the City,—the abundant supply and great pressure then enjoyed, together with the thorough drainage, (which afforded ready means of getting rid of the water) have doubtless led to its unrestricted use from the commencement, while the manner of assessment for the water rate, which bears no relation to the quantity of water used, and the consequent neglect of supervision in this respect, have brought about the present abuse of the water. It will be no easy matter to make head against a system which has taken such a deep root in the habits of the Citizens, but when it is demonstrated that there is no alternative between increased taxation for the purpose of laying down another main, and a general husbanding of the present supply, which is by no means a limited one for 50,000 inhabitants, it may be expected that the latter course will be chosen.

While thus alluding to the excessive consumption of water in Quebec, I would not wish it to be understood that there is no means of " obtaining a greater supply through the present line of pipes ;"—for,—while the pipe is

taking all the water which it can take, nearly the whole of that flowing in the night is lost instead of being stored, as may be done, to make up the defficiency of its day delivery. In the latter part of April, when there was no necessary waste to prevent freezing, it was found that all night long a steady flow of over *one hundred thousand gallons per hour* passed into the pipe at Lorette ; and as scarcely any of this could have been drawn off, the presumption is that it was running to waste through nearly all of the three thousand service pipes by which the houses are supplied. The lowest average night delivery of the pipe was eighty-eight per cent of the highest average day delivery, so that after making all proper allowances for night consumption and leakage it would appear that not more than twenty-five per cent of the water taken into the pipe at Lorette is required for consumption in Quebec. Of course, in most cities under the constant supply system, there is as much if not more water wasted than consumed, but in none that I am aware of is there so little control exercised over the consumers. This has probably arisen from the mode of assessment, and the fact of its being a new question ; also from the belief that the supply was inexhaustible—and therefore when it failed,—that there was something wrong with the works ; and hence investigations and contrivances to increase the supply in preference to husbanding it. With this general statement of the case I will proceed to describe the condition in which I found the works and then make some suggestions as to their principal requirements both in construction and management.

CONDITION OF THE WORKS.

Upon my arrival in Quebec, after preparing a plan of the pipes as laid in the city, from information obtained in the Engineers office, I proceeded to ascertain the actual quantity of water supplied by the pipe from Lorette during each hour of the twenty-four ; and to test the pressure at different points by means of guages which my assistant had brought with him, and upon which he could rely. The results of the guagings and experiments are appended to this report ;—but to make them intelligible I will explain that, with regard to the first, the actual quantity of water flowing into the pipe within a given time was easily ascertained by means of the well in the gate house at Lorette, the dimensions of which were known, as to the second a correct steam pressure guage was connected with the cap of a hydrant at different points, and the pressure upon the guage in pounds indicated the height to which the water, if free, would rise at that point. For example when all the stop gates of the pipes were fully opened, at half past nine on the morning of the 28th April, the guage indicated a pressure of only eight pounds at Mount Pleasant or a loss of head at this point of two hundred and thirty feet. This proved that if a stand pipe twenty feet high had been inserted in the pipe at that point, the water would not have flowed out of it, so great was the velocity with which it was rushing over the pipe summit at this point to its outlets in the city. If all the gates had been shut the guage of Mount Pleasant would have indicated a pressure of one hundred and six pounds instead of eigh' pounds ; as this point is two hundred and forty-four feet below the head level at Lorette. As it was, when, according to custom, the gate on the fourteen inch pipe was shut, from five to seven p. m., and the water forced round by Grande Allée to g.ve the daily supply to the high district, the gauge at Mount Pleasant rose to a pressure of seventy five pounds (equal to a head of one hundred and seventy three feet of water); the differenceof seventy-one feet head, or thirty-one pounds pressure, being the loss of head caused by friction.

Upon applying the guage in St. Rochs the pressure did not exceed thirty-five pounds, equal to a head of eighty-one feet of water ; whereas if the full pressure from Lorette were on, the head would be four hundred and sixty-nine

feet, and the guage would shew two hundred and four pounds of pressure, instead of thirty-five. This was one of the most important results of the guage, because it shewed that the loss of water at Quebec is not due to excessive pressure, and consequent leakage and waste, in Lower Town as might be supposed. On the contrary, the pressure at the corner of Prince Edward and Craig streets, in St. Rochs, was found to be almost identical with that at the corner of Fort and Buade street, in Upper Town, the guage indicating thirty-three pounds at both points, from nine a. m., to four p. m., and the water would have risen to an equal height of seventy-six feet above the street in each place;—although the first point is one hundred and thirty-six feet lower than the other. It also shewed the extent to which the pressure could be equalized by checking the flow of the water at the different gates. It was evident that the Engineer was making the most of the water, and, by dividing up the pressure and carefully regulating the gates was keeping it up to a point nearly one hundred feet higher than it would have risen to, if the gates had been open and the water left to find its own level.

Incrustations. Another fact established by the guage was that the delivery in the main was not checked or diminished by an irregular draft—the flow over Mount Pleasant being constant and the pressure there remaining uniform from nine o'clock a. m., until five o'clock p. m., at which time the water was turned up upon Grande Allée. Also, that the incrustations known to exist in the pipe, could not be increased or fostered by any occasional slackness or irregularity in the motion of the water through the pipe. With respect to these incrustations it may here be observed that they have appeared in other cities, where the water is particularly pure (and therefore possessing the highest solvent powers) and where the pipes have not been coated to protect them;—but that they do not appear to proceed beyond a certain point. At Quebec they diminish the diameter of the pipe at last half an inch, and its delivery some what more in proportion, from the rough interior surface they present;—but it is not probable that this evil will increase.

CAPACITY OF THE MAIN.

With respect to the actual capacity of the main the experiments proved that the original calculations must be considerably modified. The main was intended to deliver, in twenty-four hours, 3,000,000 imperial gallons into a reservoir at the Grande Allée, under the pressure of a head about forty-five feet lower than that now used;—the dam having been placed higher up upon the St. Charles after the preliminary report was published. Three millions of gallons daily require a delivery of three hundred and thirty-four and a three tenths cubic feet per minute, and, according to the formulæ used for calculating the flow of water in pipes,—an eighteen inch pipe, with a fall of fifteen feet per mile, (which was about the fall between the original reservoir surface, at Freemans Tannery Dam, and the Grande Allée) should deliver that quantity. The additional head of forty-five feet, afterwards obtained, should have added about fifty cubic feet per minute to the delivery of the pipe;—so that, if the formula could be relied on, the main should deliver three hundred and eighty-four cubic feet per minute. The guagings shewed that at no time in the twenty-four hours did the delivery over the Grande Allée reach three hundred cubic feet per minute and that the delivery into a Reservoir there, upon the summit, would not exceed two hundred and sixty-two cubic feet, or one hundred and twenty-one cubic feet less than the calculation. This great deficiency is to be accounted for by the fact that the summit of the Grande Allée is some twenty feet higher than the original site of Reservoir, and also by obstructions common to all similar mains, and heightened in your case by the manner in which the pipe is carried under the rivers on its course. Experiments were recently made

at New York and Jersey city upon mains of thirty-six and twenty inches diameter:—the first, two miles, and the second, six miles in length. The Jersey city main is somewhat similar in size and length to that in Quebec,—but the measured discharge was under a head of only about twenty feet, instead of one hundred and fifty,—which is the difference of level between Lorette and the Grande Allée. It was found however, in both cases, that the actual delivery of the pipe was from thirty to thirty-three per cent less than the calculated discharge by eight of the best formulæ, and the causes assigned were, "tubercular corrosion," (incrustations similar to those at Quebec), the collection of air at high points, and some sedimentary deposits at low ones. I was informed by your Engineer that his men thought some stones were in the pipe. The amount of obstruction caused by these cannot be reached by any formular,—and must remain an unknown quantity, but correcting the calculated discharge of three hundred and eighty-four cubic feet per minute by the actual results at New York and Jersey City, the reduced quantity agrees nearly enough with our guaging to shew that no important obstruction from stones can exist at Quebec,—unless indeed a portion of the reduced discharge in the American Cities is due to similar obstructions in their pipes.

Upon ascertaining the fact that nearly as much water passed through the pipe at night as in the day, and that the water could not get time to rise to supply the high levels, in consequence of its being rapidly and constantly drawn off through so many waste pipes, at and below the level of Mount Pleasant, I examined the Water Worts Act to see what provisions it contained for controlling this waste. Finding that there was no power of visitation and inspection inside the houses, I recommended that such should be at once obtained, while the Legislature was in session,—which I believe has been done. This question of waste has been the constant theme of complaint in the annual reports of other cities, and is due to the fact that water bulk for bulk, is less valuable (and also more readily frozen) than gas, and therefore a general system of supplying it by measure cannot be afforded. It is possible that some portion of the loss may be due to leakage in the street pipes,—which is more difficult of detection in Quebec than in other cities, in consequence of the pipe being laid in the same trench with the sewer, and in rock excavation. Where a pipe is imbedded in solid ground every leak of importance will force its way to the surface, and so be discovered;—but where it is in a trench filled in with stone, and near to a sewer, a large leak may exist and discharge itself into the sewer without detection. From the readiness with which the pressure was brought up in the several streets and districts when the gates were closed, I do not think there is much loss under this head;—but the fact can be only ascertained by taking each pipe by itself, and shutting off all the house services for an hour or two;—a process which would require months with the ordinary force employed.

WASTE.

Besides the ordinary waste in houses, from leaving the taps open and maintaining a constant stream in bath rooms, closets &c., a most serious one arises in the supply of manufactories—such as Tanneries, Breweries &c. These places require a large quantity of water for a few hours daily, and to save time in filling their vats and tanks the tenants call for the largest sized service pipes. Having obtained the large pipe it is too often allowed to discharge its full capacity, all the time, whether the water is used or not. There is but one mode of dealing with these cases, which is to ascertain the greatest quantity they require daily, and (as the pipes are already laid) throttle the stop-cocks so that no more than this quantity can be obtained in the twenty-four hours, compelling the establishments to have a cistern or tank erected which will collect,

while they are not working, the water required to keep them going without delay when they require it. Another source of waste is the abuse of the private hose in washing carriages and horses, where a barrel of water is required to do the work of a pailfull, without any saving of time, but only of muscle. In the same way the gutters are scoured of deposits which have no business there—and which, when carried into the sewers, cost many times more to remove them than whilst they are above ground. This mode of using the water is positively fordidden under penalty in other cities. But by far the most serious, because the most general and excusable source of waste is the universal practice of allowing the water to run to prevent freezing in cold weather, in which the example is set by the City authorities with their hydrants. I measured the quantity of water which was allowed to waste, to prevent forezing. at a hydrant, and found it to be at the rate of four hundred and eighty gallons per diem. The number of hydrants being one hundred and sixty-eight there is a daily loss of about 80,000 gallons, which is an ample supply for at least two thousand persons.

At Montreal where the thermometer has attained thirty below zero the hydrants do not waste water; nor do they freeze except in a few cases where placed too near to gulley drains,—or where there is no drainage;—and although their hydrants are upon a different plan, I am of opinion that yours can be protected from freezing without wasting water. With regard to the house waste in winter, its importance may be judged of from the fact that the quantity of water, as exhibited at the Police Office, which is wasted to prevent freezing, is more than half a gallon per minute or eight hundred and sixty-four gallons per day for each service. As there are over three thousand services in the city, it requires more water than the main could deliver at the Grande Allée to supply this waste, and therefore in cold weather, (particularly with the other sources of waste in manufacturies and elsewhere) it is impossible for the water to rise to the Cape. Of course this quantity is five or six times greater than is *necessary* to prevent freezing;—but where the habit exists, any very nice adjustment of the taps can only be expected where there is large conscientiousness.

Freezing of the Service Pipes. There are some circumstances peculiar to the mode in which your service pipes are laid which may render them more liable to freeze, than in other places. The simultaneous construction of the drainage with the water works has led to the placing of the service pipe on top of the drain pipe, and so near it as to be affected by a rush of cold air from the latter; but if the sewers and cellars are frost proof these pipes should not freeze,—their depth under ground being seven feet. The place where service pipes are most lively to freeze is where they pass through the wall. The frost passes down the side of the wall, and stone being a good conductor, the pipes are easily frozen *if in contact* with it. Wherever a pipe passes through a wall it should be surrounded with wood,—and as this precaution has not I believe been taken at Quebec, I would advise its being done. There is still the case of the pipes being exposed to frost after they are inside the buildings. If any consideration were given to this important question by builders, proprietors, and plumbers, there are few houses in which the pipes might not be so placed as to be secure from frost: but from convenience, or for appearances, the pipes are brought up in close contact with the outside walls, to be concealed by plaster—or forced into cold corners and out-buildings, instead of being brought up in the centre or body of the house, away from outside walls, &c.; or instead of being left exposed to the general warmth of the building. Where the pipes are so placed that they must freeze at night, they should be emptied by a tap in the cellar, in preference to running water to waste all night long. The manner in which your street service cocks are placed, as well as the obstruction from snow and ice in your climate prevent

your shutting off the water from the houses, otherwise it might be found preferable as a last resource to go to the trouble and expense of shutting off the services, generally, at night, and compelling consumers to provide themselves with cisterns, as the residents on the Cape must now do—rather than lay down a new main from Lorette.

Some control should therefore be exercised inside of the houses, and, as a mere matter of economy, it would be cheaper for the Corporation to pay for securing the pipes from frost, inside the houses, (if they are not prepared to compel the water tenants to do so)—and thus save the waste, than to replace it by an increased supply. If nothing like a correct public opinion can be formed by exhibiting the consequences of unnecessary waste, so that something like criminality will attach itself to the offence—for which purpose it would be justifiable to publish the names of all parties offending hereafter,—the only resource in the hands of the city authorities, short of further taxation for an enlargement of the works, is to apply to consumers, generally, the principle recommended in dealing with manufactories,—that is to throttle all the street service cocks so that the pipes would only deliver a fair domestic supply for twenty-four hours—and let the tenants construct cisterns for storing at night any surplus required during the day. It is the serious defect of all Water Works systems that from excusable ignorance in the first place, inattention or recklessness afterwards, plumbing is so done, or houses so constructed, that the water (which never freezes until it reaches the buildings) must then be allowed to waste to an extent which so reduces the pressure as to lay dry the high level, and, in your case, render the hydrants valueless in case of fire, unless by closing valves and depriving certain districts of water while the fire lasts. Besides the injury to the valves from this constant wear, there is more or less delay in case of fire in certain districts and the chance of mistake or omission in opening and closing them. Thus, after hundreds of thousands have been expended for water,—for the sake of a little trouble and a few dollars expended by the consumer in the first instance, the efficiency of the whole system is impaired. For the future the city authorities should prescribe the manner in which houses should be plumbed, so far as protection from frost is concerned;—and the water should not be turned on to any new consumer, until his pipes are inspected and found satisfactory.

MODE OF INCREASING THE SUPPLY.

It has already been stated that there is little inducement to increase the supply unless the unnecessary waste which now prevails can be checked. By the publication and enforcement of Rules and Regulations, such as are established for all similar works (and which have probably been neglected in Quebec for reasons already mentioned,) this evil may be very much reduced;—but there is a great defficiency in the present system from the want of a reservoir which formed part of the original plan. In consequence of the premature deficiency of the supply,—or rather the great excess of consumption (some three hundred per cent) over the estimated quantity required, it has been proposed to adopt a system of Reservoirs, at different levels, in order to obtain the highest possible discharge from the pipe. As this is a most important question, and one upon which opinions may be divided, I will endeavour to explain it as clearly as I can;—for while, theoretically, it promises advantages, there are practical difficulties in working it out. The capacity of the present main is in proportion to the head under which it discharges; thus while it can deliver something less than two and half millions of gallons, in twenty-four hours, at at the level of the Grande Allée near the Riding House, (which is about one hundred and forty-five feet below Lorette head level,) it could deliver about three and three quarter millions at a point two hundred feet lower—which

point would still be one hundred and thirty feet above St. Roch. Its greatest possible delivery would be in the River St. Charles where it could discharge a little more than five millions of gallons per diem, but for all the good it would do there the water might as well go round by the Falls of Lorette, as come through the pipe. The question then is, how much gain can be obtained by the use of lower reservoirs and still send the necessary supply up to Grande Allée?

Equalizing Reservoirs. It has been supposed that if two or three tanks were constructed and put in connection with the main by a self acting apparatus, (the distributing pipes attached to each tank being disconnected from each other) each district would take the supply it required, and thus the largest duty be obtained from the main. This view was based upon the supposition that the full pressure due to Lorette existed in Lower Town, and thereby caused an extra waste, which would be avoided under an equalizing system of tanks. But it has been shewn that the pressure in Lower Town has been necessarily so relieved, by regulating the stop cocks, that it does not exceed that in some parts of the Upper Town. Therefore, so long as the present relative consumption exists, the water would all find its way into the lower tanks, leaving the upper district unsupplied as at present. The thanks then would not be self acting, for it would be necessary to shut off the supply from the lower ones while the upper one was being filled. Each tank therefore must be large enough to maintain the supply to its own district while the other two were being filled and therefore must be extensive and expensive, in short, reservoirs instead of tanks.

Again, the present system of pipes is calculated for the full head of a Reservoir on the Cape. If a lower head is used their capacity is reduced, and, in the case of a lower reservoir below Mount Pleasant, the distance from the small pipe in Champlain street would be so great as to cause a great loss of head which would render the hydrants there useless in case of fire. For this reason two reservoirs only and two systems of distribution could be used; and in order the whole of the district attached to the lower one might enjoy the benefit of a fire pressure, this reservoir must be placed about the level of Mount Pleasant,—although the distributing pipes attached to it would comprise only those lying one hundred feet and more below that level. This would give to the upper reservoir on the Grande Allée a district extending about one hundred and eighty feet below it;—and to the one at Mount Pleasant,—the lower district,—on which the extreme pressure would range from two hundred and forty to two hundred and fifty-feet. This difference of pressure in favour of the latter would be required on account of the greater distance it has to send the water round towards Wolfe's Cove. Other circumstances would determine Mount Pleasant as the proper site for the construction of a second reservoir if such be required, viz: that there is no practicable site for the construction of one at a much lower level, without excessive cost. The most economical reservoirs are made upon level ground—and the more precipitous the ground the more expensive and difficult of cnstruction they become.

The number of services in the lower district being about double those in the upper one, it may be supposed that double the quantity of water will be required for the former, in which case the main would discharge about fourteen hours into the lower reservoir out of the twenty-four,—and ten into the upper one, to afford the proportionate supply. The gain which would be obtained by the use of two reservoirs would therefore be the excess of the hourly delivery of the main into the lower one, over that into the upper one, for the number of hours only, however, in which it was not discharging into the upper one; that is six thousand one hundred and eighty cubic feet per hour for fourteen hours, say 539,000 gallons daily, or about twenty-three per cent

more than if the whole supply were delivered on the Grande Allée. But inasmuch as the reservoirs cannot be made self acting, and it will therefore be found necessary to shut off the supply from the lower one for ten hours daily, the question arises why not let Lorette remain the reservoir for the lower district (at least for the present) and fill the upper reservoir during the night? In this way the largest possible delivery, consistent with the efficient supply of Upper Town, will be obtained. The objection to this is that while the upper reservoir is filling the Lower Town may be wholly or partially deprived of water,—which deprivation may however be confined to the night. There should be no difficulty in maintaining all necessary night consumption either from the upper reservoir,—or by leaving the fourteen inch valve on John street partially open.

If, as there is every reason to believe can and will be done, the waste is so checked that the additional twenty-three per cent of water to be gained by the construction of a second reservoir will not be needed, then the difficulty is at an end,---and the whole supply can be furnished by means of the one reservoir upon the Grande Allée, and the expense of the second one be saved. At all events the trial of this should first be made, for if the waste cannot be so checked that this extra quantity will not be needed, there is little hope that if given, (at the expense of a second reservoir) il will prove of much value. Strictly speaking there will be all this gain and even more,---both in quantity of water and in pressure, by feeding directly from Lorette to the lower district, instead of from a second or lower reservoir, and the latter would be more a a convenience to prevent the total or partial shutting off from the lower district during as many hours of the night as it would take to refill the upper reservoir. But as it is probable that even a partial shutting off of water from the lower district will not be needed after some inspection over the waste is fairly established, the proposition of a second reservoir need not now be entertained, but the simple principle on which the works were originally planned should be carried out, viz: The delivery of the whole supply from a high level reservoir upon the Cape. The delivery at this level will afford a greater daily average per head of the population using the water, than is given in any other city in America or in Great Britain. It will secure a steady supply, at all hours, in every house in the city, and will put a stop to the injurious opening and closing of valves, now necessary in shuffling the water round the city daily and in case of fire,---when it is always attended with more or less risk and delay.

If a second reservoir is constructed, a considerable expense must be incurred in re-arranging the distribution for the lower district as all the large pipes are now in the upper one.

One important objection to two reservoirs fed by the same pipe, is that, as the supply would be intermittent, the level of water, unless the reservoirs were very large, would be subject to great fluctuations. the water being drawn down daily nearly to bottom level and filled again. The effect of this, in very cold weather would be to convert the whole reservoir gradually in a connected mass of ice, leaving an insufficient space for water. For this reason the single reservoir which is subject to the least fluctuation is the best; and with far less size and cost will be more efficient. An account of this rising and falling of the ice, it will be necessary that the walls of the reservoir between the lines of fluctuation, should be substantial,---being made of solid masonry with a batter,---in preference to flat paved slopes as are common in milder climates. It is also desirable that every reservoir should have a good depth, in some portion of it at least, not for winter purposes only, but to prevent heating of the water in summer. In other respects its value is in proportion to the extent of the water surface whereby it feeds the largest quantity with the least loss of head.

Size of Reservoir. With regard to the size of this reservoir, which is the measure of its costs, there are several considerations to be weighed. As a mere means of regulating the supply it might be sufficient if it were only large enough to hold one day's delivery of the pipe, provided the consumption did not upon any day exceed that delivery. But as there will be particular occasions when this may arise it should, on this account alone, be large enough to hold several days supply. Again, for the purposes of a reserve, in case of accident to the country main, it would be desirable that the storage should be ample to maintain the supply until the difficulty was over. There are two possibilities in which an accident to this main would lead to unusual delays,—these are if it occurred either under the River St. Charles, or under Mr. Simard's stables. In the first case the pipe is imbedded in timber and concrete, five feet under low water, and twelve feet under high water of spring tides, and is under a constant pressure of over two hundred pounds upon the square inch (about double the ordinary pressure in a locomotive boiler,) which pressure is liable to be increased at any moment by the incautious closing of a valve. If in this, its most exposed position, the pipe should give way (and I am informed that two or three leaks have occurred there already) a week or more might elapse at certain seasons---particularly when there was much ice and snow, before it could be repaired. It is greatly to be regretted that the original plan of carrying the pipe over the St. Charles upon a Bridge, was abandoned,—and that, in going to the expense attending the manner in which the present one was laid, a duplicate one (which would have cost but a few hundred pounds extra) was not laid down at the same time, to give security in case of accident to one line. It is an established principle in Water Works (where so much depends upon a constant supply,) that all parts of the works should be as acessible as possible in case of accident; and cases have occurred, in England, where a Parliamentary Committee has thrown out plans because they proposed to carry pipes under a river without a culvert. So important was this considered that at Montreal not only was a culvert constructed under the Lachine Canal, in mid winter, at great risk and costs, but a double line of pipe was laid through it, either of which can be used in case of accident to the other. I look upon this crossing of the St. Charles as the weakest point in your system and think some provision should be made against the contingency of accident there, either by a second line of pipe, or by increased capacity in your reservoir.

In the second case, where brick and stone stables are arected over the line of the supply pipe,---I am unable to judge of the reasons which led to such an extraordinary step, but presume that if it was unavoidable, there can be no insuperable objections to the construction of a releaving arch whereby the pipe would be accessible from the ouside of the building. If the pipe should burst at this point, it might, before the water was shut off, undermine the walls, and bring down rubbish to be removed before repairs could be made.

RESERVOIR SITE.

The best site for a Reservoir is the field in which the Riding School is placed. A portion of the Corporation property—the corner adjoining the Military transit station—is nearly as favourable as to height, but not so well situated with respect to the present line of pipes; it can, however, be easily made available if the other cannot be obtained. The branch which has been laid off the eighteen inch pipe, on Grande Allée, for feeding a Reservoir, is near the corner of Desalaberry street,—a point some twenty feet lower than the summit at the Riding School. Of course no Reservoir could be placed on that portion of the Corporation property fronting on Grande Allée, because the pipe, where it goes over the summit at the Riding School, would be as high or higher

than the surface of the water in the Reservoir, and, therefore, could not draw up the supply. I suppose when this ground was selected it was not the intention to carry the large pipe along the Grande Allée to the walls as has been done, but to feed back by Mount Pleasant and the fourteen inch pipe in John street. The present disposition of the pipage is, however, much better;—as the largest pipes should always be upon the highest levels, but it involves the necessity of placing the Reservoir upon the summit. The site near the Military transit station requires more pipe, in getting in and out of the Reservoir, and is not quite so favourable as to cost and efficiency as the Riding School one; but it is the only portion of the Corporation property which could now be made available for a Reservoir. The Military ground would afford a water surface a few feet higher, an object of some importance to the houses upon the summit, and as the water could from thence be conducted into the Citadel, I presume the authorities would not object to its being occupied by a Reservoir, under restrictions as to the height of banks above the surface.

The cost of a Reservoir will depend upon the character of the rock in which it is excavated. If this is water tight the expense of lining will be saved. If otherwise it would not be prudent to provide a less sum than £15,000 for which a Reservoir to hold several days' supply can be constructed. It will not, however, be large enough to provide against a failure of the pipe under the St. Charles; and as an enlargement for this purpose, in rock excavation, would be for more expensive than a duplicate pipe at the River, I would recommend the latter course.

I will forward a plan and detailed estimate of a Reservoir, showing the mode of construction I would recommend, if the rock proves similar to that which is to be seen in other parts of the City.

DISTRIBUTION.

There is very little alteration or addition required in the distribution in connection with a summit Reservoir. The eighteen inch pipe brings the water to the walls at the corner of Grande Allée and St. Eustache street. A connection of the six inch in the latter street from Artillery street, with the eighteen inch, would give two sixes and one eight inch pipe to feed the fourteen inch in John street. This fourteen inch which was, I believe, originally intended for the Grande Allée, will be shut off at Mount Pleasant, from the eighteen inch, and will appear, therefore, to be superseded; but it will prove valuable, in case of any repairs or accidents to the main above Mount Pleasant, or to the Reservoir, or while these pipes are emptied for the purpose of making connections. There would, however, only be that portion of the fourteen inch between Claire Fontaine and Desalaberry streets which would be superseded, for the purposes of distribution, as it would be necessary to bring a fourteen inch down the former street from the Grande Allée, to feed the John street main; because the small pipes above referred to would give but a portion of the delivery from Lorette. From the corner of St. Eustache street and Grande Allée, a four inch pipe should be carried directly to the highest point on St. Denis street, either through the Gate (or along the Glassis, if allowed) without being connected with any other pipe. Another pipe of the same size should be laid in the same trench, and in like manner, to the head of Ste. Geneviève street. I understand there is plenty of four inch pipe on hand, by connecting these highest points directly with the eighteen inch pipe, there would be a constant supply to the hydrants, for the protection of the valuable property otherwise so exposed in case of fire. As the Reservoir would be nearly abreast the termination of the pipe in Champlain street it would be easy to connect with it whenever it was found necessary.

The eighteen inch pipe would thus feed one eight inch and two four inch pipes inside the walls; and one fourteen inch, one eight inch, and two six inch ones outside the walls, to and past the fourteen inch main in John street, which would be sufficient to give the whole delivery from Lorette.

ASSESSMENT.

Allusion has been made to the mode of assessment, as one of the causes which has led to the abuse of the water by consumers, and the neglect of a proper supervision over the consumption by the authorities. An uniform water rate of two shillings in the pound, without reference to the quantity of water use, gives the tenant the idea that he has paid for all the water which his service pipe will deliver, and it is wasted, not often wilfully but in ignorance, under the supposition that the works are calculated to keep all the services going at their full capacity. The flow of water, under the various circumstances connected with its distribution in a city, and the rules by which it is governed, are little understood by the public generally; and to this cause, chiefly, may be attributated the abuse of one of the greatest benefits citizens enjoy. This ignorance leads to unreasonable demands with regard to service pipes and disregard of the opinion of the responsible officer. The citizen by reason of his water rate looks upon the supply as something of which he is to get the greatest amount for his money, and views the engineer as the person whose duty it is to put him off with the lowest quantity. He therefore passes him by, and goes directly into the Corporation or Committee, and lobbies out an order for the size of pipe he has demanded, which in nine cases out of ten is far beyond his utmost wants, but he has gained his point, and the Engineer, finding his voice powerless against the demands of an influential rate-payer, is discouraged. Thus it is that notwithstanding the enormous pressure in your pipes, a pressure which makes a two inch pipe in Quebec, equal to a three inch one in Montreal, you have given fifty per cent more of the largest size service pipes to your tenants than is done even in Montreal where the same system of control obtains (and where there are three times as many water takers), and of sizes unnecessary in any city. There are no less than fifteen places which have *four inch* service pipes, for any one of which an inch pipe would probably furnish all the water used, and in some cases more than is required; and, although most of them are public buildings, two are breweries, and one a cabinet factory. Thus, single establishments have service pipes of the same size as that which is laid in rue St. Anne in Upper Town, on which there are thirty-four services; or in St. Joseph street, St. Roch, on which there are nearly one hundred services.

The relative quantities of water discharged in twenty-four hours from the different sizes of pipe in use under the different heads at the place named are given in the appendix,—and although these will be reduced by the *length* of the service in each case a simple inspection is sufficient to shew the absurdity, as well as the effect of granting to importunate applicants whatever size of pipe they may think, or may have been told they require, by an ignorant or designing plumber, with whom the larger the pipes the greater the weight of lead sold.

Again the uniform poundage rate did away with any desire on the part of the authorities to ascertain the proportionate consumption, by each rate payer, with a view to make a proportionate charge, and thus nothing was known of what was going on inside of the houses;—and no power of ascertaining it existed. So the works were virtually abandoned to the consumers, and of course those on the highest levels,—though the heaviest rate payers, would be the first to suffer.—This is not the fault of individuals but of a system, and as it is evident that the most perfect works may be rendered comparatively

useless under a bad system, I think I will not be going beyond the line of my instructions if in giving my "advice and suggestions" for the purpose of increasing the supply, through the present line of pipes, I refer to the question of management—for it is by management chiefly that any thing is to be effected "with the present line of pipes" in checking the waste. Without this check, Reservoirs will prove insufficient—and another line of pipes or a continuance of the present limited supply will be unavoidable.

MANAGEMENT.

In the principal cities of the United States, where the Water Works are the property of the Corporation, it has been found in most cases impracticable to manage them directly by the City Councils. Where the management of an important hydraulic work is vested in a large body, which has besides the control of all other civic affairs—nothing like personal responsibility exists, especially if this body is changed wholly or partially every year. Nor is it just that a Corporation Committee, the members of which were perhaps not elected with a view to their serving in the Water Committee, and who are also upon several other less important Committees,—should be charged with the supervision, and be held accountable for the management of a work, which has many specialities to be studied, and which requires prompt and regular attention. The main defect in the system is that the powers of Corporation Committees are generally limited to the recommending, or otherwise, of appointments, expenditures, &c.,—the decision upon which take place in full council. This latter body frequently has little opportunity of knowing the merits of questions upon which they are thus called to decide, and are therefore more liable to be influenced by feeling, prejudice, or outside pressure. If every administrative act in the management of large and important works becomes the subject of debate among twenty members the chances are, either that no prompt action will be taken, or that the wrong conclusion will be arrived at as often as the right one. These annual revolutions in the Corporation and Committees lead to changes in the management, and often in the employés of the work. The latter not having the same men to deal with, are not only uncertain of their position, and therefore irresolute, but are to a certain extent freed from control during the annual interregnum which accompanies the breaking up of the old and the forming of the New Committee. The new members postpone business until they shall have had time to become familiar with the question, and this, in courtesy, is granted; while retiring members absent themselves, postpone or evade action, in order not to assume any responsibility, or (if they are candidates for reelection) give a weapon to be used against them at the polls. Thus the works suffer, oftentimes more by inaction than by any action taken. Under such a system there can be neither order nor responsibility,—to secure which time and motive must be given. Therefore it has been found that a small body of Water Commissioners, either elected by the people, as is done in Hamilton, or by the Council upon the nomination of the Mayor, as is done in New York,—and holding office for a term of five years, forms the proper Board to which the management of the Water Works and drainage of the City should be intrusted.—Having a special charge there is a special responsibility,—and there is the time for becoming acquainted with their duties, and the motive for doing so.

In conclusion I would sum up what I consider the principal requirements.

First.—A strict supervision over the manner in which the water is used, and an enforcement of the usual Rules and Regulations, as well as the throttling of the supply in all cases where waste is ascertained.

Second.—The construction of a summit reservoir, and the delivery of the whole supply first, into it.—When this proves insufficient, the summit reservoir

can be filled daily and an upper district be apportioned to it, by actual experiment, so that the largest quantity may be given, to the remainder of the city, directly from Lorette.

THIRD.—The addition to the distribution recommended in connection with the Reservoir at Grande Allée.

FOURTH.—A duplicate main at the crossing of the St. Charles—and provision for access to it where built upon, at Mount Pleasant.

With these provisions, which can be attained at a total cost of £25,000 to £30,000, I think the necessity for an additional main (for which no provision has been made in the head works at Lorette) will be avoided.

I trust you will pardon the necessary plainness with which I have felt it my duty to speak, and without which the true state of affairs could not be explained. The same system in Montreal is rapidly producing the same effects;—but yours, having been longer in operation, has culminated sooner.

I take this occasion to acknowledge the valuable aid which has been afforded to my assistant, Mr. Kennedy, and myself, by your Engineer Mr. O'Donnell, who has spared no pains to further our investigations, and who has in my judgment done all that was possible, to diminish the inconvenience arising from the cause mentioned in this report.

I have the honor to be,

Sir,

Your Obedient Servant,

THOS. C. KEEFER.

TABLE 1.

Experiments on the Quebec Water Works—April, 1860.

Date.	Time.	Quantity of water in cubic feet per minute taken into the main at Lorette.	Pressure in main at Mount Pleasant—in lbs.	Loss of head due to friction in in main at Mt. Pleasant—feet.	Pressure at corner of Prince Edward & Craig st. St. Roch, in lbs.	Pressure at corner of Fort and Buade streets, in lbs.	
April 24th	9.48 A. M.	....	...	...	...	...	49 lbs. pressure at corner Dauteuil and St. John streets.
"	10.00 "	....	22½	192	34	34	
"	10.30 "	....	22½	192	34	32	
"	11.00 "	....	22½	192	33	31	
"	11.30 "	310.67	22	193	33	32½	
"	12.00 "	300.58	22	193	33	32½	
"	12.30 P. M.	305.02	22	193	33	34	
"	12.47 "	....	...	...	...	...	19 lbs. pressure at cor. of Mount Carmel and Descarrieres [streets.
"	1.00 "	294.92	22½	192	33	34	
"	1.15 "	305.64	...	...	...	...	
"	1.30 "	303.02	22½	192	33	34	
"	1.45 "	....	...	...	...	...	1½ lbs. pressure at corner Laporte and St. Denis streets.
"	1.53 "	....	...	...	...	...	8 " " " St. Geneviève and St. Ursule.
"	2.00 "	333.30	22½	192	37	...	
"	2.04 "	....	...	...	...	...	No water at corner Grand Allee & St. Augustin streets.
"	2.17 "	....	...	...	...	...	5 lbs. pressure at cor. St. Julia and St. Augustin streets.
"	2.30 "	320.30	22½	192	37	...	
"	3.00 "	277.25	22½	192	38	32	
"	3.05 "	290.01	...	...	...	...	
"	3.30 "	311.08	22½	192	33	32	
"	4.00 "	283.45	22½	192	...	34	22 lbs. pressure at cor. St Paul and St. Nicholas streets.
"	4.22 "	....	...	...	...	...	15 " " " " and St. Paul streets.
"	4.30 "	313.10	22½	192	...	34½	
"	4.37 "	....	...	...	...	...	11½ " " " Sous-le-Fort and St. Peter streets.
"	5.00 "	293.91	23	191	...	...	
"	5.02 "	318.13	...	...	...	...	
"	5.15 "	....	27	182	...	...	
"	5.30 "	305.63	33	168	2	...	
"	5.45 "	....	34½	165	...	...	
"	6.00 "	262.60	35	163	2	...	11 lbs. pressure at cor. Grand Allee & Lachevrotière sts.
"	6.30 "	207.05	35½	161	2	...	16 " " " "
"	6.45 "	....	70	83	...	...	17 " " " "
"	6.50 "	....	...	...	...	...	17 to 44 " " "
"	7.00 "	161.60	74½	73	2	...	43½ lbs. " " "
"	7.30 "	171.70	75	72	2	...	44 " " " "
"	8.00 "	282.80	29	177	12	...	
"	8.30 "	295.73	25	186	20	...	
"	9.00 "	288.46	26	184	23	...	
"	9.30 "	289.02	27	182	28	...	
"	10.00 "	281.18	29	177	28	31	
"	10.30 "	268.05	29	177	32	31½	
"	11.00 "	234.58	29½	176	32	...	21 lbs. pressure at corner St. Peter and St. Paul streets.
"	11.30 "	277.03	30	175	...	...	34 " " " Des Fossés and St. Roch sts.
"	12.00 "	293.91	30	175	...	...	
25th	12.30 A. M.	278.76	31	173	...	...	33 " " " St. Francis and Church streets
"	1.00 "	278.76	31	173	...	...	
"	1.10 "	....	...	...	...	...	32 " " " Des Fossés and Church streets.
"	1.30 "	278.76	31	173	...	...	35 " " " Des Fossés and St. Roch sts.
"	2.00 "	278.76	31	173	...	38½	22 " " " St. Peter and St. Paul streets.
"	2.15 "	....	...	...	...	...	19 " " " St. Peter and Sous-le-Fort sts.
"	2.30 "	293.91	31	173	...	39	
"	2.40 "	....	...	...	...	...	19 " " " St. Geneviève & St. Ursule sts.

TABLE 1.—(*Continued.*)

Experiments on the Quebec Water Works—April, 1860.

Date.	Time.	Quantity of water in cubic feet per minute taken into the main at Lorette.	Pressure of main at Mount Pleasant in lbs. per square inch.	Loss of head due to friction in main at Mount Pleasant, in feet.	Pressure of corner of Fort and Buade streets, in lbs.				
April 25th	3.00 A. M.	303.00	31	173	...	35½	lbs. pressure at corner		Des Fossés and St. Roch streets.
"	3.30 "	296.94	31½	172	...	34	" "	"	Des Fossés and Church streets.
"	4.00 "	293.91	31½	172	...	20½	" "	"	Sous-le-Fort and St. Peter streets.
"	4.15 "	....	...	...	...	33	" "	"	St. Nicholas and St. Paul streets.
"	4.30 "	293.91	31½	172	...	23	" "	"	St. Peter and St. Paul streets.
"	4.45 "	....	...	...	38½				
"	5.00 "	281.18	31½	172	...	18½	" "	"	St. Geneviève & St. Ursule streets.
"	5.30 "	309.06	31½	172	...				
"	5.45 "	....	31	173	...	16½	" "	"	Sous-le-Fort and St. Peter streets.
"	6.00 "	299.97	30½	174	37				
"	6.20 "	....	...	...	34				
"	6.30 "	303.00	30	175	35	16½	" "	"	St. Geneviève & St. Ursule streets.
"	6.45 "	....	29	177	...				
"	7.00 "	286.68	28½	178	33				
"	7.10 "	....	...	...	34				
"	7.30 "	298.15	27	182	32				
"	7.45 "	....	26½	183	...				
"	8.00 "	315.12	25½	185	30				
"	8.15 "	....	25	186	...				
"	8.30 "	307.85	24½	188	...				
"	8.45 "	....	24	189	...				
"	9.00 "	298.96	24	189	...				
"	9.30 "	290.88	...	...	...				
"	10.00 "	305.42	...	...	...				
"	10.30 "	295.73	...	...	...				
"	11.00 "	310.58	...	...	...				

REMARKS ON TABLE 1.

From the commencement of these gaugings, till 5.00 P. M. on the 24th, the city was supplied by St. John street, the Stop Cocks leading to the Lower Town being either shut or throttled, (as marked on plan) so as to retain the water in the higher levels. From 5.00 P. M. to 7.30 P. M., some of the Stop Cocks (marked thus X on plan) were closed so as to confine the water and send it to the Grand Allee and other highest levels. After 7.30 P. M., the water was allowed to descend to Lower Town as before. This is the usual method of supplying the city, and has been followed since May, 1859.

RESULTS OF THE TABLE.

The average delivery of the main during the 24 hours given in the Table, is 287,824 cubic feet per minute = 17,269 cubic feet per hour = 414,456 cubic feet, or 2,582,890 gallons per diem.

The *highest average* delivery occurred between 11.30 A. M. and 2.30 P. M. of the 24th, and was 309,181 cubic feet per minute.

The *lowest average* delivery (when feeding by St. John street), occurred between 10.30 P. M. of the 24th, and 2.00 A. M. of the 25th, inclusive, and was 273,326 cubic feet per minute, or 88$\frac{4}{10}$ per cent. of the highest average during day.

The difference between the lowest average night delivery, and the highest average day delivery, was 36 cubic feet per minute nearly.

Assuming that one-fourth of this or 9 cubic feet per minute was used in the night, and that 50 cubic feet per minute is constantly required to supply leaks, and about 214 cubic feet per minute, or nearly 75 per cent. of the whole quantity of water delivered into the city, must have been wasted.

TABLE 2.

Experiments on the Quebec Water Works—April, 1860.

Date.	Time.	Quantity of Water in cubic feet per minute taken into the main at Lorette.	Pressure in main at Mount Pleasant, in lbs. per square inch.	Loss of head due to friction in main at Mount Pleasant—feet.
26	12.00	318.15	.....	.....
"	1.00	315.12	.....	.....
"	2.00	303.00	.....	.....
"	2.30	.....	20¼	197
"	3.00	317.54	19½	199
"	4.00	327.24	.....	.....
"	5.00	303.00	.....	.....
"	5.30	290.88	.....	.....
"	6.00	273.91	.....	.....
"	6.30	254.52	.....	.....
"	7.00	266.64	.....	.....
"	7.30	210.89	.....	.....
"	8.00	207.04	.....	.....
"	8.30	266.94	.....	.....
"	9.00	271.49	.....	.....

From 12.00 M. to 5.00 P. M., the City was supplied by St. John Street in the same manner as on the 24th and 25th (Table 1,) except that the stop cocks leading to Lower Town were less throttled. Between 5.00 and 8.00 P. M. the water was turned up to Grand Allée so as to give a pressure on the summit. After 7.30 P. M., the stop cocks were being arranged to feed over the Grand Allée without pressure on the summit.

The average delivery of the main from 12.00 M. to 5.00 P. M., was 314 cubic feet per minute.

TABLE 3.

Experiments on the Quebec Water Works—April, 1860.

Date.	Time.	Quantity of Water in cubic feet per minute taken into the main at Lorette	
27	6.00 A. M.	284.21	
"	7.00 "	276.34	
"	8.00 "	287.86	
"	9.00 "	288.46	
"	10.00 "	290.88	6 lbs. pressure at corner of Grande Allée and St. Augustin Street.
"	10.05 "	....	7 do do St. Amable and do do.
"	10.15 "	....	No pressure at corner of { St. Amable and Lachevrotière Street. Grande Allée and do do.
"	10.30 "	280.78	
"	10.50 "	....	35 lbs. pressure at Mount Pleasant.
"	11.00 "	280.78	
"	11.30 "	284.82	
"	12.00 "	282.80	
"	12.30 P. M.	286.03	
"	1.00 "	286.03	
"	1.30 "	281.18	
"	2.00 "	274.26	
"	3.00 "	280.78	

TABLE 3—(*Continued.*)

Experiments on the Quebec Water Works—April, 1860.

Date.	Time.	Quantity of Water in cubic feet per minute taken into the main at Lorette.	
27	4.00 P. M.	283.61	
"	5.00 "	281.18	
"	6.00 "	244.82	} Stop Cocks throttled to retain water on Grande Allée.
"	7.00 "	249.67	
"	8.00 "	249.67	
"	9.00 "	271.49	
"	9.30 "	....	15½ lbs. pressure at corner St. Peter and St. Paul Streets.
"	9.50 "	....	24 do do St. Paul and St. Nicholas Streets.
"	10.00 "	264.21	30 do do St. Roch and Des Fossés do.
"	10.30 "	269.06	41 do do St Ursule and St. John do.
"	10.40 "	....	21 do do do and St. Anne do.
"	10.50 "	....	17½ do do do and St. Geneviève Streets.
"	11.00 "	293.91	12½ do do St. Dennis and Laporte do.
"	11.10 "	....	38½ do do Descarrières and Mount Carmel Streets.
"	11.30 "	279.69	
"	12.00 "	287.85	
"	12.30 A. M.	293.91	
"	12.45 "	....	98 do do Craig and Prince Edward Streets.
"	1.00 "	303.00	
"	1.15 "	....	95 do do Des Fossés & Craig, St. Nicholas & St. Paul Sts.
"	1.20 "	....	96 do do do and St. Roch Street.
"	1.30 "	296.94	
"	2.00 "	288.45	22½ do do at Mount Pleasant.
"	2.25 "	....	9½ do do at corner Artillery and St. Augustin Streets.
"	2.45 "	....	6 do do St. Ursule and St. Geneviève Streets.
"	3.00 "	289.23	
"	4.00 "	315.12	
"	5.00 "	324.81	
"	6.00 "	324.81	
"	7.00 "	339.36	
"	8.00 "	336.94	
"	8.30 "	336.94	
"	9.00 "	336.94	
"	9.15 "	....	6 lbs. pressure at corner St. Ursule and St. Ann Streets.
"	9.25 "	....	12 do do Jupiter and St. John do.
"	9.35 "	....	8 do do at Mount Pleasant.
"	9.55 "	....	9 do do do do.

REMARKS ON TABLE 3.

From the evening of the 26th till about 11.30 P. M. on the 27th, the water was all delivered over the Grande Allée by shutting the stop cock on the 14 inch pipe at Mount Pleasant. From the summit, on Grande Allée, the water ran freely down towards St. Lewis Gate, being partly drawn off by the 8 and 6 inch pipes in Lachevrotière and St. Augustin Streets. The stop cocks leading to the lower parts of the City were throttled, in much the same way as when feeding by John Street, so as to retain the water on the high levels as shewn by the pressure guage.

Between 11.30 P. M. on the 27th, and 12.30 A. M. of the 28th, all stop cocks which would have an influence on the flow of the water were opened for the purpose of finding the greatest night consumption and waste, and also to find the natural level of the water under these circumstances.

The stop cocks were all allowed to remain in this state until about 10.30 A. M. on the 28th.

RESULTS OF THE TABLE.

The average delivery of the main between 10.30 A. M. and 5.00 P. M. on the 27th, was 282.03 cubic feet per minute or 2,530,870 gallons per diem—nearly all over Grande Allée, (except 4 inch in John Street). The average delivery between 7.00 and 9.00 A. M. of the 28th, was 337,545 cubic feet per minute, none going over Grande Allée. The quantity delivered over Grande Allée summit, without back pressure was about 83½ per cent of that delivered over Mount Pleasant with about 11 lbs. per square inch back pressure (at the level of the pipe.)

TABLE shewing the number of Gallons of Water which would be delivered in 24 hours from lead pipe of short lengths. As ascertained by experiments made June 19th, 1860, by Mr. O'Donnell, Engineer, Quebec Water Works.

NOTE.—These experiments shew the relative capacity of the different sizes—as well as the great quantity of water which can be taken by the Consumer daily. The actual delivery into houses would be less than the above in proportion to the length of the service in each case.

Date.		Size of pipe in inches.	Quantity of water which could be delivered in 24 hours.	
1860. June 19	From Hydrant at corner St. Nicholas and St. Paul Streets	1	Gallons. 141,384	
		3/4	69,120	
		1/2	46,416	
		3/8	35,328	
"	Do Des Fossés and St. Rochs Streets	1	141,384	
		3/4	69,120	
		1/2	51,840	
		3/8	37,464	
"	Do Craig and Prince Edward Streets	1	141,384	Ordinary pressure the stop cocks throttled as usual.
		3/4	74,040	
		1/2	52,728	
		3/8	37,032	
"	Do St. Peter and Leaden Hall Streets	1	124,416	
		3/4	63,480	
		1/2	43,800	
		3/8	30,504	
"	Do Buade and Du Fort Streets	1	185,216	
		3/4	70,680	
		1/2	48,600	
		3/8	34,944	
"	Do St. Ursule and St. Ann Streets	1	172,800	
		3/4	84,048	
		1/2	55,536	After 5.00 P. M. when the water was shut off from St. Rochs and Lower Town to supply the Cape.
"	Do St. Dennis and Laport Streets	1	88,872	
		3/4	50,160	
		1/2	35,736	
		3/8	25,920	
"	Do Des Fossés and Craig Streets	1	Pressure too great to measure with 1 inch.	
		3/4	141,384	
		1/2	88,872	
		3/8	67,608	About 75 per cent of full pressure on.
"	Do. St. George and St. Augustin Streets.	1	145,704	
		3/4	88,872	
		1/2	63,480	
		3/8	46,416	
		1/2	69,120	
"	Do Jupiter and St. John Streets	1	145,704	
		3/4	75,864	
		1/2	50,160	
		3/8	34,944	Under ordinary pressure.
"	Do Mount Pleasant	1	135,216	
		3/4	63,480	
		1/2	44,424	
		3/8	30,504	
"	Do Grande Allée and Lachevrotière Str.	1	124,416	Water turned up under about 75 per cent of the full pressure that could be produced if requisite.
		3/4	43,200	
		1/2	34,560	
		3/8	21,432	

1860.

STATEMENT shewing the places where services pipes of one inch and upwards have been granted in Quebec, as given by Mr. O'Donnell, Engineer Quebec Water Works, &c.

To McCallum's distillery off main	18"	pipe at	Savageau street,	two	1 inch	services	governed by	1 inch	cocks,	
" Boswell's brewery,	6	"	St. Valier	"	one	1	"	"	1	"
" Bisset's foundry,	6	"	"	"	"	1	"	"	1	"
" Chateau St. Lewis,	8	"	Place d'Armes	"		1	"	"	1	"
" Printing Office (now shut)	4	"	Buade street,	"		1	"	"	1	"
" Hotel Dieu Nunnery,	6	"	Palace	"	"	4	"	"	4	"
" Ursuline Convent,	8	"	St. Ursule	"	"	4	"	"	4	"
" Good Shepherd Convent,	8	"	Lachevrotière	"		4	"	"	2	"
" Marine Hospital,	6	"	Panet street,	"		4	"	"	0	"
" Archiepiscopal Palace,	12	"	Mountain	"	"	4	"	"	0	"
" House of Assembly,	12	"	"	"	"	4	"	"	0	"
" Seminary,	6	"	Hope	"	"	4	"	"	4	"
" University,	6	"	George	"	"	4	"	"	2	"
" Court House,	8	"	St. Lewis	"	"	4	"	"	0	"
" Jail,	4	"	Stanislaus	"	"	4	"	"	2	"
" City Hall,	8	"	Ursule	"	"	4	"	"	0	"
" McCallum's brewery,	6	"	Paul	"	"	4	"	"	0	"
" Lepper's brewery,	6	"	"	"	"	4	"	"	2	"
" Drum's Cabinet Factory,	6	"	"	"	"	4	"	"	0	"
" Jesuits' Barracks,	14	"	Fabrique	"	"	4	"	"	4	"

1860.

ESTIMATE of the number of Water Takers in Quebec, by Mr. O'Donnell, Engineer Quebec Water Works.

Families	5373
Nuns and their pupil boarders	2160
Soldiers, their wives and children	600
Seminary, Priests and pupil boarders	100
University	40
Normal School	25
Orphan Asylum	40
St. Bridget's do.	35
Steam Engines (nineteen) Total P	200
Horses in city (say)	1200
Cows " "	500
Tanneries that are supplied from house services	21
Ship-yards (one steams timber)	3
Estimating an average of five persons to each family, total number of Water takers would be	29,865